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Effect of seed pelleting and foliar nutrition on growth and yield traits of summer sesame (*Sesamum indicum* L.)

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Abstract

A field study, effect of seed pelleting and foliar nutrition on growth and yield of summer sesame cv. GJT 5 was conducted at the Sagdividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh, during the summer of 2022, using a factorial randomized block design. The experiment comprised five seed pelleting treatments (P_0: non-pelleted, P_1: seed pelleted with urea @ 20 g/kg, P_2: seed pelleted with DAP @ 10 g/kg, P_3: seed pelleted with $ZnSO_4$@ 4 g/kg and P_4: seed pelleted with $MgSO_4$ @ 4 g/kg) and five foliar nutrition treatments (F_0: No spray (control), F_1: foliar nutrition with urea @ 1 % at 30 DAS, F_2: foliar nutrition with DAP @ 1 % at 30 DAS, F_3: foliar nutrition with $ZnSO_4$ @ 1 % at 30 DAS and F_4: foliar nutrition with $MgSO_4$ @ 1 % at 30 DAS). Among the seed pelleting treatments, seed pelleting with $ZnSO_4$ @ 4 g/kg (P_3) and among the foliar nutrition, foliar nutrition with DAP @ 1 % at 30 DAS (F_2) recorded the maximum number of branches per plant (5.40), plant height (86.27 cm), number of capsules per plant (85.60), number of seeds per capsule (66.91), seed yield per plant (20.53 g), biological yield per plant (78.73 g), 1000 seed weight (3.49 g), harvest index (25.88 %), seed yield in (25.88 kg/ha) with the lowest days to 50 per cent flowering (37.40 days) and days to maturity (78.80 days).

Keywords

foliar nutrition; seed pelleting; seed yield; sesame

Introduction

Sesame (*Sesamum indicum* L.) is the oldest known oilseed crop, domesticated nearly 3000 years ago and the first known oil consumed by man. It belongs to the order *Tubiflorae* and the family *Pedaliaceae*. It is known as the "Queen of oilseeds" and an orphan crop because it receives little research attention. However, the demand for sesame seeds has increased in the last two decades due to high oil quality, protein content, antioxidant content and wide adaptability in extreme climatic and edaphic environments (1). Africa has been considered the primary centre of sesame origin and it spread early through West Asia to India, China and Japan, which became secondary distribution centres (2). Sesame is a self-pollinated crop with an average cross-pollination of 4 to 5 %. However, the amount of out-crossing ranges from 0 to 50 % depending upon the pressure of pollinating agents, whereas wind plays no part in natural cross-pollination (2). Sesame seeds are an essential source of oil (44–57 %), proteins (18–25 %), carbohydrates (13.5 %) and ash (5 %). They also have medicinal and nutritional value (1).

One of the most promising techniques that can be adopted in direct sown small-seeded crops like sesame is seed pelleting, which modifies the microenvironment of the seed in favour of the seed. It provides macro and micronutrients essential for seedling establishment and protects the plants from pests and diseases during their early growth stages (3).

Cultivation of sesame faces certain physiological constraints like heavy flower drop, slow dry matter accumulation and poor partitioning of assimilates from source to sink. These problems can be overcome by foliar application of plant nutrients essential for plant growth and development. Foliar application of macro and micronutrients at critical stages of crop growth facilitates a quick supply of nutrients, promoting photosynthesis and mobilization of assimilates to sink and yield (4). Both seed pelleting and foliar nutrition improve nutrient uptake, thereby the best management option for higher growth and yield in summer irrigated sesame (5). The aim is to enhance photosynthesis nutrient mobilization and boost yield, providing valuable insights for optimizing sesame crop management strategies. The study evaluates the effects of foliar application of key macro and micro-nutrients, as identified by previous researchers, combined with seed pelleting to address physiological constraints in summer irrigated sesame. Elements such as nitrogen (N), phosphorus (P), potassium (K), zinc (Zn), boron (B) and iron (Fe) have been highlighted in earlier studies for their role in improving plant growth, photosynthesis, nutrient uptake and assimilate partitioning. Foliar feeding is an effective method of nutrient application, as it facilitates the rapid and direct absorption of nutrients through the leaf surface, bypassing soil-related nutrient limitations such as poor availability, leaching losses and fixation. This method ensures the timely supply of nutrients during critical crop growth stages, thereby enhancing photosynthesis, nutrient assimilation and the efficient translocation of assimilates from source to sink.

Materials and Methods

A field study on the effect of seed pelleting and foliar nutrition on growth and yield of summer sesame cv. GJT 5 was conducted at the Sagdividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh, during the summer of 2022, using a factorial randomized block design. The experiment comprised five seed pelleting treatments (P_0: non-pelleted, P_1: seed pelleted with urea @ 20 g/kg, P_2: Seed pelleted with DAP @ 10 g/kg, P_3: seed pelleted with $ZnSO_4$@ 4 g/kg and P_4: seed pelleted with $MgSO_4$ @ 4 g/kg) and five foliar nutrition treatments (F_0: no spray (control), F_1: foliar nutrition with urea @ 1 % at 30 DAS, F_2: Foliar nutrition with DAP @ 1 % at 30 DAS, F_3: foliar nutrition with $ZnSO_4$ @ 1 % at 30 DAS and F_4: Foliar nutrition with $MgSO_4$ @ 1 % at 30 DAS). The characters *viz*., days to emergence, days to 50 per cent flowering, number of branches per plant, days to maturity, plant height (cm), number of capsules per plant, number of seeds per capsule, seed yield per plant (g), biological yield per plant (g), 1000 seed weight (g), harvest index (%) and seed yield (kg/ha) were recorded. It was analyzed using a randomized block design (Factorial) per the standard formula (6). Five competitive plants per treatment in each replication will be selected randomly to record observations on different quantitative characters in this experiment. Their averages will be used in the statistical analysis. The selection of the GJT 5 cultivar can be justified based on its being well-suited to the specific agro-climatic conditions of the target region, ensuring better growth, resilience and high yield potential. Some treatments could focus on sustainable agricultural practices, such as reduced chemical input through applying pelleting treatments. A medium is created to encapsulate a package of materials that can positively influence the microenvironment surrounding each seed. This approach ensures the supply of essential nutrients from the earliest crop growth stages, promoting optimal development.

Results and Discussion

Effect of seed pelleting treatments

Irrespective of foliar nutrition treatments, the effect of different seed pelleting treatments was significant for all the characters studied except days to emergence. Significantly the maximum number of branches per plant (5.40), plant height (86.27 cm), number of capsules per plant (85.60), number of seeds per capsule (66.91), seed yield per plant (20.53 g), biological yield per plant (78.73 g), 1000 seed weight (3.49 g), harvest index (25.88 %) and seed yield (1073.64 kg/ha) was recorded in seeds pelleted with $ZnSO_4$ @ 4 g/kg (P_3), while they were observed the minimum (3.17, 66.33 cm, 68.83, 53.70, 10.04 g, 50.30 g, 2.68 g, 20.53 % and 666.59 kg/ha) in control (P_0) significantly. Significantly, the lowest and highest days to 50 per cent flowering (37.40 days and 48.07 days) and days to maturity (78.80 days and 85.80 days) were recorded in seeds pelleted with $ZnSO_4$ @ 4 g/kg (P_3) and control (P_0), respectively (Table 1-2 and Fig. 1–12). Research indicates that similar results were achieved in sesame (3, 5, 7).

Seed pelleting is encapsulating a seed with a small quantity of inert material, just large enough to produce a globular unit of standard size to facilitate precision planting. The inert material creates natural water-holding media and provides minor nutrients to young seedlings (8, 9).

Seed pelleting is a method of applying various materials to the seed that can enhance the seed's quality in terms of physiological, physical, and health attributes. Seed pelleting also serves as a method of applying needed material in such a way that it affects the seed or soil at the seed-soil interface. Seed pelleting makes it easy to handle small and irregularly shaped seeds. Seed pelleting with micronutrients/bio-stimulants/biological species not only improves the health and physiological quality of seeds by protecting the seeds from fungal and insect attack but also improves seed and soil relationships by enriching the *rhizosphere* region of the seed.

Table 1. Effect of seed pelleting and foliar nutrition on days to emergence, days to 50 per cent flowering, number of branches per plant, days to maturity, plant height (cm) and number of capsules per plant

Factors	Days to emergence	Days to 50 % flowering	Number of branches per plant	Days to maturity	Plant height (cm)	Number of capsules per plant
P_0	12.00	48.07	3.17	85.80	66.33	68.83
P_1	11.67	45.07	3.76	84.13	75.87	71.63
P_2	11.40	43.07	4.16	83.60	81.13	76.17
P_3	11.27	37.40	5.40	78.80	86.27	85.60
P_4	11.33	40.20	4.42	81.73	81.20	79.79
S.Em±	0.20	0.78	0.10	1.56	1.45	1.64
C.D. at 5 %	NS	2.22	0.27	4.44	4.13	4.66
F_0	11.47	44.20	3.89	85.93	73.20	71.24
F_1	11.80	42.13	4.31	82.07	80.53	78.74
F_2	11.47	41.00	4.57	79.20	84.47	82.90
F_3	11.40	42.80	4.13	82.73	77.13	75.77
F_4	11.53	43.67	4.00	84.13	75.47	73.39
S.Em±	0.20	0.78	0.10	1.56	1.45	1.64
C.D. at 5 %	NS	2.22	0.27	4.44	4.13	4.66
P_0F_0	12.00	48.67	3.00	91.33	61.00	65.31
P_0F_1	12.33	48.00	3.22	84.00	70.00	71.45
P_0F_2	11.67	47.00	3.29	80.33	61.33	67.41
P_0F_3	12.00	48.33	3.19	85.33	72.00	70.52
P_0F_4	12.00	48.33	3.15	88.00	67.33	69.45
P_1F_0	11.33	47.00	3.48	86.67	72.33	67.05
P_1F_1	12.33	44.00	3.81	83.67	76.00	72.31
P_1F_2	11.33	43.00	4.12	80.33	81.00	80.70
P_1F_3	11.33	45.33	3.75	84.00	75.67	70.08
P_1F_4	12.00	46.00	3.63	86.00	74.33	68.02
P_2F_0	11.33	45.00	4.04	85.67	75.67	71.41
P_2F_1	11.67	42.00	4.15	83.33	84.67	77.76
P_2F_2	11.67	40.67	4.40	80.67	91.67	85.07
P_2F_3	11.33	43.00	4.12	83.67	77.00	74.51
P_2F_4	11.00	44.67	4.07	84.67	76.67	72.12
P_3F_0	11.33	38.67	4.62	82.00	79.33	79.46
P_3F_1	11.33	37.00	5.94	78.00	92.33	89.01
P_3F_2	11.33	36.00	6.50	75.00	96.67	93.23
P_3F_3	11.00	37.33	5.18	79.00	82.00	85.16
P_3F_4	11.33	38.00	4.78	80.00	81.00	81.16
P_4F_0	11.33	41.67	4.31	84.00	77.67	72.94
P_4F_1	11.33	39.67	4.45	81.33	79.67	83.15
P_4F_2	11.33	38.33	4.56	79.67	91.67	88.09
P_4F_3	11.33	40.00	4.42	81.67	79.00	78.57
P_4F_4	11.33	41.33	4.37	82.00	78.00	76.21
S.Em+	0.45	1.75	0.21	3.49	3.25	3.66
C.D. at 5 %	NS	NS	0.61	NS	9.24	NS
CV %	6.80	7.08	8.89	7.30	7.20	8.30

Seed pelleting is the more straightforward and common technique followed in direct sown crops as it needs initial vigour for relentless crop growth and development. Pelleting provides a medium to construct a package of materials that will help influence each seeds' micro-environment by supplying nutrients from the earlier stages of the crop. Usually, seeds vary in size, shape and colour, which leads to difficulty in precision seeding and uniform

Table 2. Effect of seed pelleting and foliar nutrition on number of seeds per capsule, seed yield per plant, biological yield per plant, 1000 seed weight, harvest index and seed yield

Factors	Number of seeds per capsule	Seed yield per plant (g)	Biological yield per plant (g)	1000 seed weight (g)	Harvest index (%)	Seed yield (kg/ha)
P_0	53.70	10.04	50.30	2.68	20.53	666.59
P_1	60.17	14.84	62.34	3.24	23.61	788.05
P_2	62.93	16.60	70.27	3.33	23.39	821.71
P_3	66.91	20.53	78.73	3.49	25.88	1073.64
P_4	64.60	18.06	74.32	3.41	24.13	886.82
S.Em$\pm$	1.41	0.43	1.40	0.05	0.63	26.39
C.D. at 5 %	4.00	1.24	3.98	0.14	1.78	75.03
F_0	56.14	12.81	58.42	3.00	22.14	713.47
F_1	65.05	17.59	70.55	3.30	24.59	897.66
F_2	65.13	19.88	74.33	3.36	26.21	1070.06
F_3	62.29	15.48	68.19	3.26	22.50	800.36
F_4	59.69	14.32	64.46	3.21	22.11	755.26
S.Em$\pm$	1.41	0.43	1.40	0.05	0.63	26.39
C.D. at 5 %	4.00	1.24	3.98	0.14	1.78	75.03
P_0F_0	45.29	9.25	38.08	2.58	24.57	603.74
P_0F_1	62.12	10.38	53.18	2.72	19.69	711.34
P_0F_2	48.21	10.80	55.32	2.83	19.58	776.96
P_0F_3	57.90	9.93	52.99	2.67	19.15	624.04
P_0F_4	54.99	9.85	51.96	2.62	19.65	616.89
P_1F_0	55.60	10.24	48.78	2.85	21.41	668.04
P_1F_1	62.25	16.91	69.20	3.36	24.47	815.01
P_1F_2	65.38	19.79	73.51	3.39	26.91	971.76
P_1F_3	60.02	15.01	64.84	3.32	23.15	755.70
P_1F_4	57.59	12.24	55.37	3.28	22.12	729.72
P_2F_0	58.04	12.75	61.50	2.98	20.63	736.13
P_2F_1	64.12	18.00	73.84	3.45	24.36	814.42
P_2F_2	68.09	21.94	78.69	3.49	27.96	1012.27
P_2F_3	63.72	15.75	71.84	3.40	21.84	794.62
P_2F_4	60.69	14.55	65.50	3.31	22.17	751.12
P_3F_0	61.12	17.16	73.79	3.40	23.23	804.83
P_3F_1	70.31	22.84	80.77	3.51	28.30	1242.00
P_3F_2	74.31	24.20	83.97	3.60	28.37	1476.15
P_3F_3	65.37	19.67	78.25	3.48	25.11	985.10
P_3F_4	63.43	18.77	76.90	3.45	24.39	860.14
P_4F_0	60.64	14.65	69.97	3.22	20.87	754.62
P_4F_1	66.48	19.81	75.79	3.48	26.12	905.55
P_4F_2	69.68	22.65	80.18	3.50	28.22	1113.16
P_4F_3	64.44	17.02	73.07	3.45	23.22	842.34
P_4F_4	61.75	16.18	72.58	3.40	22.22	818.45
S.Em+	3.14	0.97	3.13	0.11	1.40	59.00
C.D. at 5 %	NS	2.77	NS	NS	3.97	167.78
CV %	8.82	10.52	8.08	6.05	10.30	12.06

plant spacing. Physical seed enhancement techniques like seed pelleting produce more rapid and synchronous germination across seedbed environments, mainly when their seed size is minimal. Higher plant height might be attributed to the increased availability of nutrients due to the presence of polymer coats and fertilizers in the seed pelleting mixture, facilitating the early germination of seeds. Early attainment of the autotrophic stage due to greater vigour in the initial stages of plant growth might be the reason for more branches and dry matter production

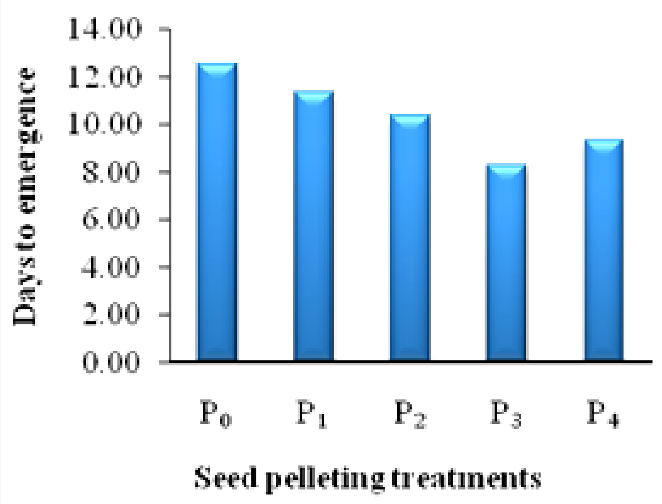

Fig. 1. Effect of seed pelleting on days to emergence.

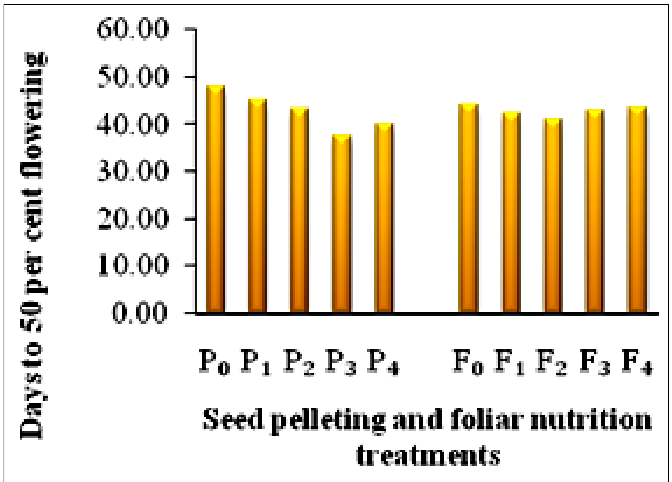

Fig. 2. Effect of seed pelleting and foliar nutrition on days to 50 % flowering.

by plants produced from pelleted seeds (7). Research indicates that similar results were achieved in sesame (3). Increased photosynthetic rate due to higher nutrient uptake and efficient translocation of photosynthates from source to sink might be the reason for higher yield attributes with seed pelleting. Research indicates that similar results were achieved in sunflowers (10). The cumulative favourable effect of enhanced growth and yield attributes might have resulted in higher seed yield. Research indicates that similar results were achieved in groundnuts (11).

Effect of foliar nutrition treatments

Irrespective of seed pelleting treatments, the effect of different foliar nutrition treatments was significant for all the characters studied except days to emergence. Significantly, the maximum number of branches per plant (4.57), plant height (84.47 cm), number of capsules per plant (82.90), number of seeds per capsule (65.13), seed yield per plant (19.88 g), biological yield per plant (74.33 g), 1000 seed weight (3.36 g), harvest index (26.21 %) and seed yield (1070.06 kg/ha) was recorded in foliar nutrition with DAP @ 1 % at 30 DAS (F_2), while they were noted the minimum (3.89, 73.20 cm, 71.24, 56.14, 12.81 g, 58.42 g, 3.00 g, 22.14 % and 713.47 kg/ha, respectively) in control (F_0). Significantly, the lowest and highest days to 50 per cent flowering (41.00 days and 44.20 days) and days to maturity (79.20 days and 85.93 days) were recorded in foliar nutrition with DAP @ 1 % at 30 DAS (F_2) and control (F_0), respectively (Table 1-2 and Fig. 1–10). Research indicates that similar results were achieved in sesame (5, 12-14). Plant roots may not correctly take the nutrients applied through chemical fertilizer due to constraints in the soils' physical and chemical properties. Through foliar nutrition,

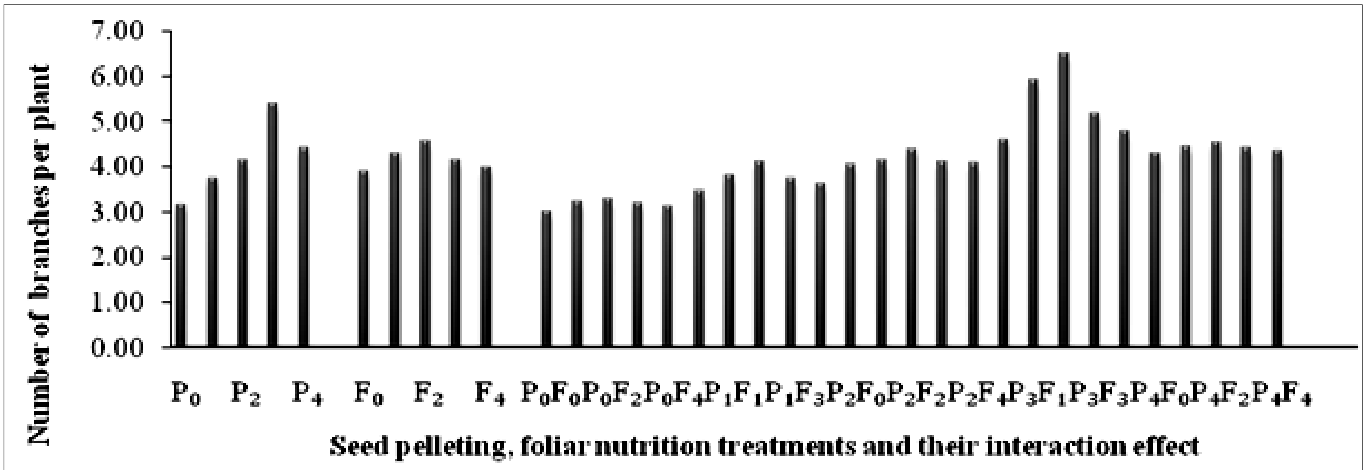

Fig. 3. Effect of seed pelleting and foliar nutrition on number of branches per plant.

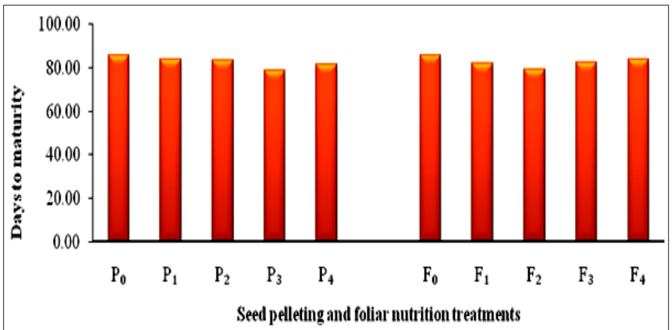

Fig. 4. Effect of seed pelleting and foliar nutrition on days to maturity.

nutrients are brought to the immediate vicinity of the metabolizing area of the plant, thereby avoiding the leaching and volatilization losses (15). This aids in better nutrient uptake and utilization by the crops

Among the macronutrients, nitrogen is a major structural component of the plant cell. It plays a vital role in plant metabolism and synthesizes proteins, amino acids and nucleic acids. Phosphorus is essential for forming protoplasm, cell division and developing meristematic tissues and it hastens nodule formation. Foliar nutrition is an effective method for correcting deficiencies and overcoming

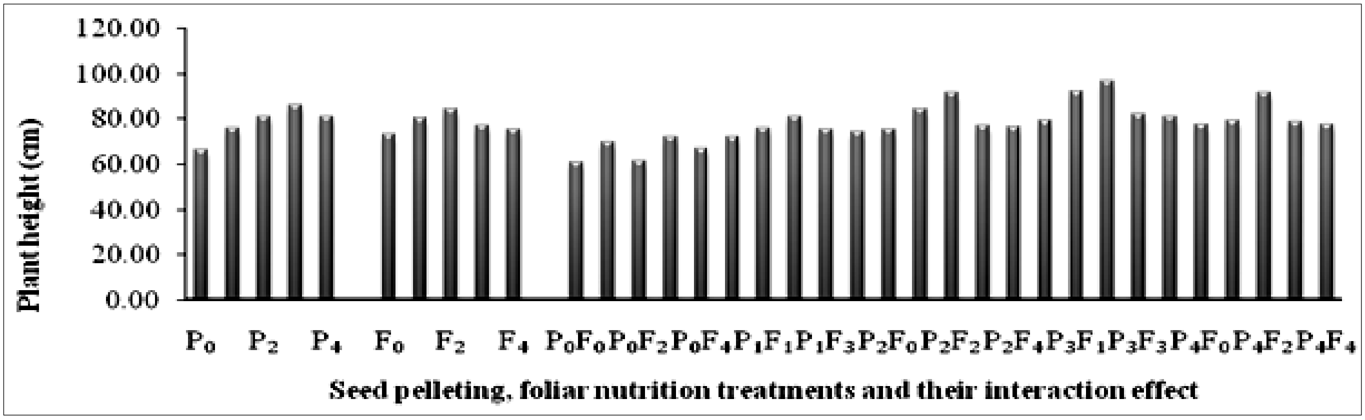

Fig. 5. Effect of seed pelleting, foliar nutrition and their interaction on plant height (cm).

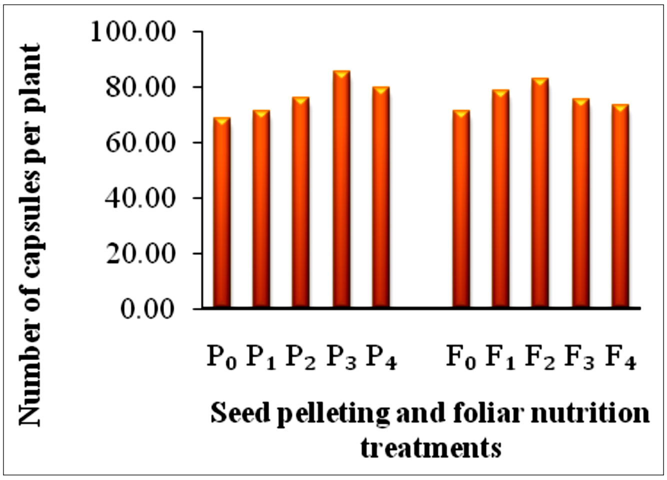

Fig. 6. Effect of seed pelleting and foliar nutrition on number of capsules per

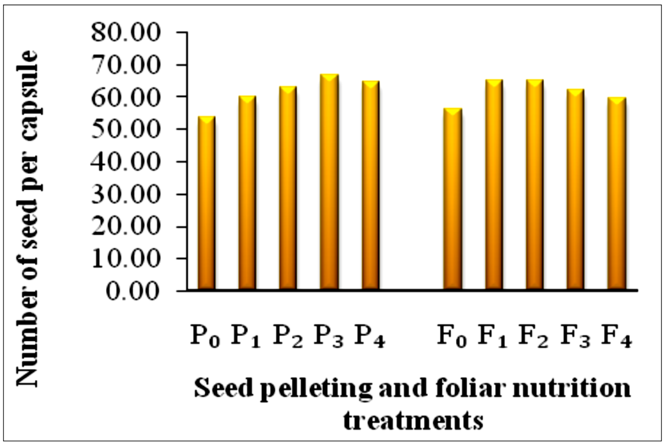

Fig. 7. Effect of seed pelleting and foliar nutrition on number of seed per capsule.

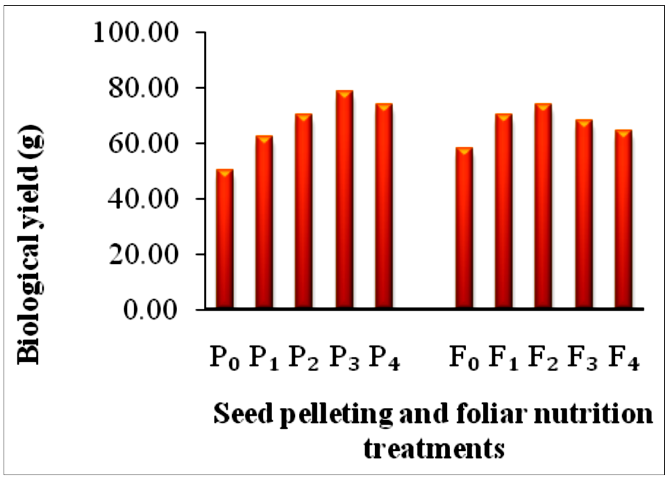

Fig. 9. Effect of seed pelleting and foliar nutrition on biological yield (g).

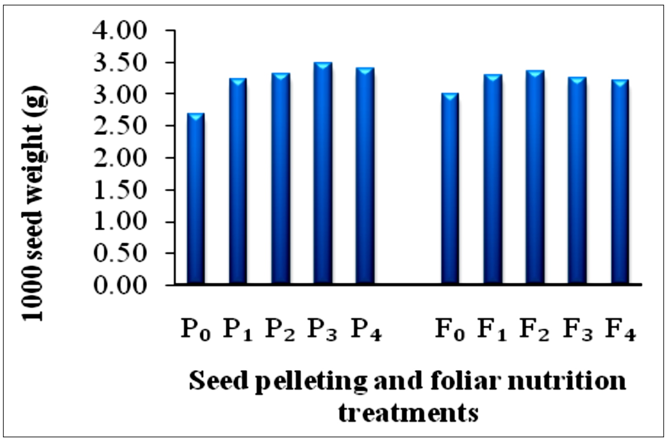

Fig. 10. Effect of seed pelleting and foliar nutrition on 1000 seed weight (g).

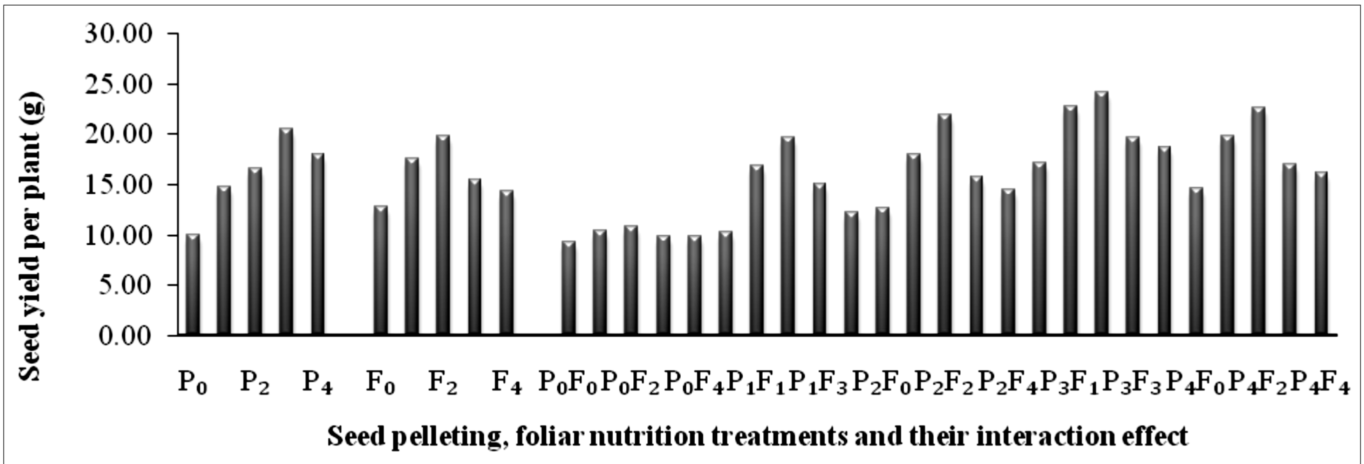

Fig. 8. Effect of seed pelleting, foliar nutrition and their interaction on seed yield per plant (g).

the soils' inability to transfer nutrients to the plant. Availability of essential nutrients and trace minerals from the soil may be limited at times by root distribution, soil temperature, soil moisture, nutrient imbalances and other factors. Foliar nutrition can help to maintain a nutrient balance within the plant, which may not occur strictly with soil uptake (16). The formulation type and the application time determine the effectiveness of foliar-applied nutrients. Foliar nutrition is 8-10 times more effective than soil application. Foliar spray stimulates an increase in chlorophyll production, cellular activity and respiration. It also triggers a plant response to increased water and nutrient uptake from the soil (17).

Macronutrients, micronutrients and plant growth regulators present in the combined nutrient formulation might stimulate cell division and enlargement, ultimately resulting in taller plants with more branches. Higher nutrient uptake and photosynthetic rate resulted in more dry matter accumulation. Research indicates that similar results were achieved in sesame (18). The increase in the seed yield with nutrient spray can be ascribed to the superiority in growth attributes and yield attributes due to the plants' easy availability and efficient utilization of nutrients. Research indicates that similar results were noticed in safflower (19).

Interaction effect of seed pelleting and foliar nutrition treatments

The interaction effect of seed pelleting and foliar nutrition treatments (P × F) was found significant for the number of branches per plant, plant height (cm), seed yield per plant, harvest index (%) and seed yield (kg/ha). Significantly, the highest number of branches per plant (6.50), harvest index (28.37 %) and seed yield (1476.15 kg/ha) were recorded in P_3F_2 (seed pelleting with $ZnSO_4$ @ 4 g/kg and foliar nutrition of DAP @ 1.0 % at 30 DAS). It was followed by P_3F_1 (seed peg wlletinith $ZnSO_4$ @ 4 g/kg and foliar nutrition of urea @ 1.0 % at 30 DAS) with 5.94 branches per plant, 28.30 per cent harvest index and 1242.00 kg/ha seed yield. Significantly, the highest plant height (96.67 cm) and seed yield per plant (24.20 g) was recorded in P_3F_2 (seed pelleting with $ZnSO_4$ @ 4 g/kg and foliar nutrition of DAP @ 1.0 % at 30 DAS). It was statistically at par with P_3F_1 (seed pelleting with $ZnSO_4$ @ 4 g/kg and foliar nutrition of urea @ 1.0 % at 30 DAS), P_2F_2 (seed pelleting with DAP @ 4 g/kg and foliar nutrition of DAP @ 1.0 % at 30 DAS) and P_4F_2 (seed pelleting with $MgSO_4$ @ 4 g/kg and foliar nutrition of DAP @ 1.0 % at 30 DAS) with 92.33 cm, 91.67 cm and 91.67 cm plant height and 22.84 g, 21.94 g and 22.65 g seed yield per plant in that order. Significantly the lowest number of branches per plant (3.00), plant height (61.00 cm), seed yield per plant (9.25 g) and seed yield (603.74 kg/ha) were recorded in control (P_0F_0: non-pelleted seed without foliar nutrition spray), while significantly the lowest harvest index (19.15 %) was recorded in P_0F_3 (non-pelleted seed with foliar nutrition of $ZnSO_4$ @ 1.0 % at 30 DAS) (Table 1-2 and Fig. 3, 5, 8, 11 and 12). Research indicates similar results were achieved in safflower and sesame (19, 5).

Conclusion

Among the seed pelleting treatments, seed pelleting with $ZnSO_4$ @ 4 g/kg (P_3) and among the foliar nutrition, foliar nutrition with DAP @ 1 % at 30 DAS (F_2) recorded the maximum number of branches per plant (5.40), plant height (86.27 cm), number of capsules per plant (85.60), number of seeds per capsule (66.91), seed yield per plant (20.53 g), biological yield per plant (78.73 g), 1000 seed weight (3.49 g), harvest index (25.88 %), seed yield in (25.88 kg/ha) with the lowest days to 50 per cent flowering (37.40 days) and days to maturity (78.80 days). These results demonstrate the practical application of seed pelleting with $ZnSO_4$ and foliar nutrition with DAP to optimize crop performance, ultimately improving productivity and profitability for farmers. Adopting these practices can help mitigate common physiological challenges in sesame cultivation, such as poor nutrient uptake and low yields, thereby contributing to sustainable and efficient farming.

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Authors' contributions

RBM was involved in the research activities and field establishment and writing of the research article. JBP and JRS corrected and proofread the research article. AVB were involved in statistical analysis work of the data collected during the research and participated in the sequence alignment. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: The Authors declare that there is no conflict of interest.

Ethical issues: None

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